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Broad Capabilities Required of Future RAAF Command Support Systems

J. Clothier & J. O'Neill

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J. Clothier & J. O'Neill

Final Report on Task Air 93/025
"RAAF Command Support Working Group Study"

DSTO-CR-0006

ABSTRACT

This report presents the results of a 12-month study by DSTO investigating the broad capabilities required of future RAAF Command Support Systems. A key finding is that broad capabilities can be specified, but user requirements are subject to change and environments are needed to support such changes. The broad capabilities are split into Command Support System capabilities and Information System capabilities to facilitate defining such environments.

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EXECUTIVE SUMMARY

A. Introduction

DAFPOL tasked DSTO to define the broad capabilities required of future RAAF Command Support Systems. The study, in which over 100 people were interviewed throughout the command chain from ACAUST to the OCWG and COSQN, also examined Air Command's requirement for sector air defence, logistics, and personnel information. Although no time horizon was placed on the Study, the capabilities outlined in the Report are likely to be achieved within the next 10 to 15 years.

This report, which presents the results of a 12-month study by DSTO, addresses the broad capabilities required of future RAAF command support systems. The work was completed as an introductory report to a project definition study for a new Air Command Support System. The Air Command Support System will be developed as part of the JP2030 project. The requirement for Command Support Systems is recognised by the 1994 Defence White Paper which listed Command, Control and Communications as a Key Role.

B. Current Command Support System Capabilities

This report has adopted the following definition of a Command Support System:

"A Command Support System exists to facilitate the mission of the organisation."

For missions to be completed successfully, four levels of fusion are required within organisations: sensor fusion, data fusion, information fusion and knowledge fusion. In the development of RAAF command support systems, the major effort has been put into sensor fusion (NADACS) and data fusion (AHQTS, AHQLAN). Rudimentary information fusion has occurred (BACSS) in isolation from other systems. To date, no knowledge fusion has taken place.

C. Approach to Defining Broad Capabilities

The ADF Command and Control Information Systems Plan has developed on the understanding that:

"The user requirement for a Command Support System is never static, and will always evolve with experience."

The statement is valuable as it recognises the dynamics of the issue. However, the Plan does not consider the properties or qualities of Command Support Systems which change user requirements in themselves. The main thrust of this document concerns this issue of changes in the requirements of command support.

A clear distinction has been drawn between Command Support Systems and Information System capabilities. The benefit of this approach is that capabilities unique to Command Support Systems can be separated from those unique to general Information System capabilities. It is possible also that such an analysis will be conducted when procuring future systems. All of the general assets of Information Systems, such as hardware, networks, databases and middleware, will be procured independently of, and separately to, the software which deals with its main business functions, namely, command and control.

D. Command Support System Capabilities

Three important concepts underlie the broad capabilities and operations of a Command Support System. They recognise:

- Individual commanders have information requirements which depend on their current situations and individual backgrounds. This means that the information requirements for given individuals and situations cannot be pre-specified completely. Commanders can tailor their requirements as their situations change.
- Individual commanders complete their assigned tasks by applying their necessary knowledge, required information, tools for manipulation of the information, and views of the information which supports the tasks they are performing. As such tools, tasks, views and information all change over time, commanders must be able to transform their varied tools, tasks, views and information to meet new situations and changing requirements.
- Individual commanders may operate in environments which are independent of Information System implementation issues. This means that the commanders' contexts are those of their organisations and current situations, and not of the information system.

Users of a Command Support System require a wide variety of tools. There are three main categories of tools: distributed decision-making tools; situation awareness tools; and situation assessment tools. Distributed decision-making tools permit the organisations in which users are operating to be modelled within the software system.

The primary future quality of such systems is their ease of use. Usability will be enhanced by enabling users to effect often radical shifts in the facilities available to them. A Command Support System does not provide merely a pre-defined set of services. It acts as a supportive environment for the creation of services tailored to meet the requirements of individuals, groups and organisations in given situations.

E. Information System Capabilities

Interoperability of Information Systems is the key to providing the functionality required by users of Command Support Systems. Our current concept of interoperation through simple message-based systems is insufficient as a medium to deliver the command support requirements of the future. Future Information Systems need to enhance the following capabilities:

- Co-operation to permit the joint completion of tasks.
- An object-oriented, open, standards-based approach to information system development.
- Middleware should be included to provide a high-level platform-independent environment to the development, maintenance, and run-time support for distributed applications.
- Architectures and standards necessary for distributed object management should be adopted.

Integration of Information Systems would imply the global naming of data items and consistency between all Information Systems—even though integration of all Information Systems is very difficult, according to the information technology community. Integration will occur at the component level where *component* is defined as a whole Information System. Component-oriented integration is useful as it models the system as a network of interacting components, avoiding any standardisation on individual architectures and enabling the independent definition of components so that components can be used in different architectural configurations to meet requirements as they evolve. Not only does the new Air Command Support System need to use many existing information systems, it also needs to interoperate with a number of other RAAF, ADF, Government and civil Information Systems.

F. Communications

Studies are underway to determine how the Defence Fixed Networks can migrate to systems employing standard, open, non-proprietary interfaces and protocols. The adoption of international standards for military communications will enable a dynamic distribution of computing resources and communication capacities across command centres. Another key consideration to be faced when developing a new Air Command Support System are the step-wise increases in capacity and performance developed by such a migrating system. How to make the best use of currently-evolving communication infrastructures is a key issue for a future Air Command Support System.

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ACAUST	Air Commander Australia
ACSS	Air Command Support System
ADF	Australian Defence Force
ADFDIS	Australian Defence Force Distributed Intelligence System
ADFORMS	Australian Defence Force Formatted Message System
ADIZ	Air Defence Identification Zone
AEW&C	Airborne Early Warning and Control
AHQ	Air Headquarters
AHQLAN	Air Headquarters Local Area Network
AHQTS	Air Headquarters Tasking Server
ASMA	Air Staff Management Aid
AUSTACCS	Australian Tactical Army Command Support System
AUSTEO	Australian Eyes Only
BACSS	Basic Air Command Support System
BVR	Beyond Visual Range
CAMM2	Computer Assisted Maintenance and Management Version 2
CAP	Combat Air Patrol
CCIS	Command and Control Information System
CJFAHQ	Commander Joint Forces Australia Headquarters
CORBA	Common Object Request Broker Architecture
COSQN	Commanding Officer Squadron
COTS	Commercial-Off-The-Shelf
CSS	Command Support System
DJFHQ	Deployable Joint Force Headquarters
DIO	Defence Intelligence Organisation
DSDN	Defence Switched Data Network
DSTO	Defence Science and Technology Organisation
DAFPOL	Director Air Force Policy
GOSIP	Government Open Systems Interconnection Profile
HQADF	Headquarters Australian Defence Force
HQNORCOM	Headquarters Northern Command
IS	Information System
ISO	International Standards Organisation
ITU	International Telecommunications Union
JCSE	Joint Command Support Environment
JORN	Jindalee Operational Radar Network
JOTS	Joint Operations Tactical System
LCOCSS	Land Command Operational Command Support System
LHQ	Land Headquarters
MHQ	Maritime Headquarters
MIST	Maritime Intelligence Support Terminal
NADACS	National Air Defence and Air Control System
NATO	North Atlantic Treaty Organisation
OBU	Ocean Surveillance and Information System Baseline Upgrade
OC	Officer Commanding

OCWG	Officer Commanding Wing
OPSO	Operations Officer
OS	Operating System
RAAF	Royal Australian Air Force
ROE	Rules of Engagement
SADC	Sector Air Defence Commander
SAR	Search And Rescue
TS	Top Secret
UAV	Unmanned Aerial Vehicle

1. Introduction

1.1. Background

Recent strategic documents have highlighted the increasing importance of Command, Control and Communications. In 1993, the Strategic Review document listed Command, Control and Communications as a Support Role. In 1994, the Defence White Paper listed Command, Control and Communications as a Key Role. Effective Command, Control and Communications enables increased leverage of the ADF's limited resources.

Under Task Air 93/025, DAFPOL tasked DSTO to provide support to the RAAF Command Support Working Group in determining the broad capabilities required of RAAF Command Support Systems. The main focus of the work was to be the command chain from ACAUST to the OCWG and COSQN. The requirements of squadrons were to be addressed indirectly through those of wings. Also included in the study were Air Defence, logistics and personnel aspects of Command Support Systems.

The specific objectives of the Task were to:

(i) Perform a context analysis of RAAF Command Support Systems in relation to other ADF Command Support Systems and information systems;

(ii) Derive the scope and terms of reference for the Project Air 5218 - Air Command Support System definition study;

(iii) Determine the key decisions and decision-makers at a representative set of RAAF Command Centres;

(iv) Determine the original information sources along with the information sources and flows required to support the key decisions and decision-makers identified in (iii);

(v) Develop Prototype systems to elicit and validate information flows and user requirements; and

(vi) Propose a specification of user requirements for RAAF Command Support Systems.

Task Air 93/025 has three major outputs:

- A document entitled *RAAF Command and Control: An Organisational Analysis Perspective* which summarises the findings of objectives (iii) and (iv).
- A document entitled *Prototype User Interfaces for Future RAAF Command Support Systems* and associated Prototype which presents the results of objectives (v) and (vi).
- A document entitled *Broad Capabilities Required of RAAF Command Support Systems. Final Report of Task Air 93/025 RAAF Command Support Working Group Study* which addresses the broad capabilities required of RAAF Command

Support Systems and includes the outputs of objectives (i) and (ii).

This report, therefore, constitutes the third of the major outputs of Task Air 93/025.

1.2. Aim

The aim of this paper is to specify the broad capabilities required of future RAAF Command Support Systems.

1.3. Changing Scope of Project Air 5218

Task Air 93/025 was conceived initially as a precursor study to Project Air 5218—Air Command Support System (ACSS). Project Air 5218 is now part of the JP2030 project. JP2030 is responsible for addressing Command Support System requirements at strategic and operational level headquarters.

When Task Air 93/025 was defined, Project Air 5218 planned to fund a project definition study for the ACSS. As the Major Capability Submission for Project 5218 was refined, the additional need to include the National Air Defence and Air Control System in the project definition study for ACSS was identified. As a result, Task Air 93/025 has not studied the NADACS in great depth, and consequently, NADACS issues may not be represented fully in this document. Another DSTO study gives a detailed assessment of the Air Defence Command and Control system—Reference 2 describes the Air Defence Command and Control system and identifies several further requirements for information technology support in this area.

1.4. Defining a CSS

There are many definitions of a CSS in terms of command and control implications and information systems aspects. One of the key problems in building a CSS, in fact, is the difficulty in defining what a CSS actually is.

The definition of a CSS to be adopted by this paper is that:

"A CSS exists to facilitate the mission of the organisation"

Figure 1 presents the basic framework of a CSS in support of an organisation's mission. The mission for the RAAF can be presented as the integration of aircraft, aircrew, controllers and sensors performing particular air tasks at given times from a set of bases. A CSS supports its commanders by ensuring that all these assets and elements are in the right places at the right times. A CSS supports its commanders when monitoring these elements and factors which may influence the results of future missions.

Four levels of fusion are required to achieve the CSS objectives[1].

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[1] The four levels of fusion presented in this document should not be confused with the JDL 4 level data fusion model which is used for situation awareness. For more information on the JDL model, see E. Waltz and J. Llinas "Multisensor Data Fusion", Artceh House Inc, Norwood MA, 1990.

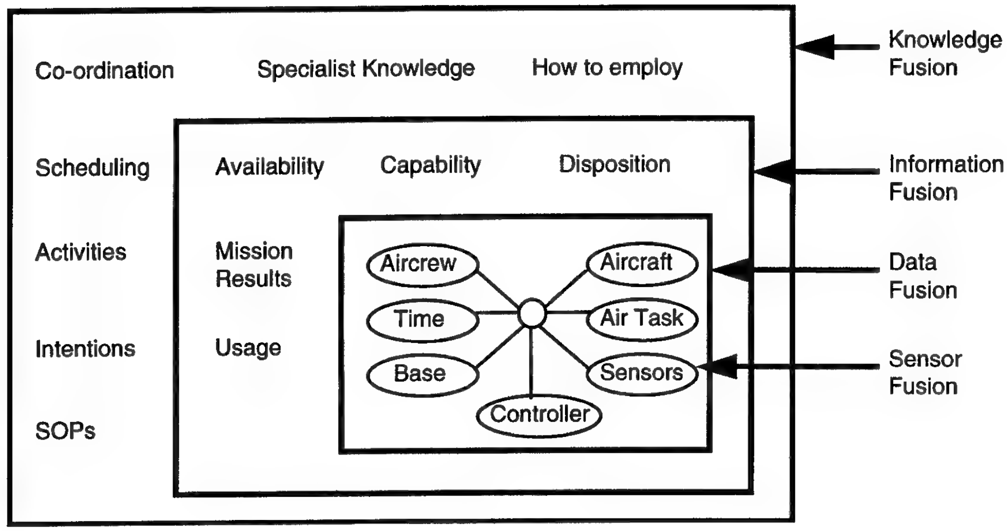

Figure 1. *Fusion of knowledge, information, data and sensors are required for the successful execution of missions.*

- *Sensor fusion* is concerned with the integration of information from a range of sensors. For example, the SADOC integrates radar pictures from many different radars at different locations.
- *Data fusion* entails monitoring the performance of the mission. For the RAAF, data fusion consists of integrating data from aircraft, aircrew, bases and sensors for particular missions at particular times. Many people may perform this monitoring at several locations and, when their data is fused, provide different perspectives of missions. For example, the SADC and pilots may have very different perspectives of the same air defence mission.
- *Information fusion* integrates all elements required to perform missions at the right times, which requires information about the availability, capability and disposition of resources, including both own and enemy forces. Once a mission has been executed, information on the result is required via feedback loops and different mission reports which confirm and maintain accounting details such as resource usage figures.
- *Knowledge fusion* integrates all the knowledge employed to execute missions. To cite an example, for particular types of mission it is necessary to know the capabilities of aircraft and aircrews, based on the perceived importance, difficulties, and complexities of the mission. Mission scheduling is shaped by information on resources, their availabilities and capabilities. For more complex missions, co-ordination will be required between the various participating elements. The manner in which the mission is performed may be based on SOPs, but its successful completion may require various specialists to provide their expert knowledge on how best to employ the resources to achieve the mission.

The data, information and knowledge required by operators varies widely between individuals who each have their own expertise, experiences and methods of making decisions.

1.5. Problems with the Current System

Current computer support to RAAF Command and Control and the NADACS is ageing. Weaknesses in the air defence computer systems have revealed as a result of detailed examination (Reference 1). Various investigations have revealed that information technology support in the RAAF Command and Control system comprises a set of disparate systems having little connectivity.

The Basic Air Command Support System (BACSS) is related to the RAF Air Staff Management Aid. It is essentially a text-based bulletin board system which provides rapid and secure communications to *Secret* level. Users of BACSS have criticised the system on a number of counts: it is difficult to use; its availability is limited, and it is not compatible with the current ADFORMS messaging system and open systems standards. In some measure the problem of the BACSS availability was alleviated by the BACSS Extension initiative. In a more positive light, however, BACSS can be considered the forerunner of what is now known as *Groupware,* that is, computer software that enables groups in widely disparate locations to interact and solve problems co-operatively.

The rapid tasking of air assets is essential for effective air operations. The Air Headquarters Tasking Server was introduced to provide a computer system secure to *Secret* level for operational taskings by ACAUST and the AHQ Operations Centre. As well it provided a secure database for Air Command operational tasks. This is updated manually from the message system, but is without any direct electronic links to the air tasking systems of any wings or squadrons.

To integrate some of the RAAF's disparate computer systems, the AHQLAN project has installed a high bandwidth secret LAN to deliver operational, logistics and administrative computer support to each desk in AHQ. Under the AHQLAN project, connections will be made to remote systems using various elements of the Defence Switched Data Network (DSDN).

AHQLAN allows outputs from different computer systems to be displayed on individual workstations. For example, BACSS and AHQTS are available from single workstations but there is still no integration or interoperation between the systems themselves. Several other inadequacies and weaknesses in the RAAF Command and Control computing environment are listed.

- At present the computing and communications infrastructure to support a RAAF-wide Command and Control system is inadequate. Not all elements of Air Command have access to BACSS.
- The integration of sensor and data fusion occurs manually in the air defence environment.
- Situation awareness displays are limited to the Recognised Air Sea Pictures produced at the tactical level.

- There is no integration of data from strategic wide area surveillance assets.
- Intelligence information to classifications of *Secret* or below is limited.
- Information on logistics, maintenance and personnel is stored on isolated ISs, hence does not support operations directly.
- There is little automation of any planning or other decision-making activities.
- Staff often have to rely on telephones and voice or facsimile message systems in order to monitor situations and to gain information for planning—however, BACSS plays an important role here.
- There is no integration and interoperation of RAAF systems such as BACSS, AHQTS, logistics, computer maintenance, and intelligence systems.
- There is no integration and interoperation of RAAF computer systems with other ADF Command Support Systems—air pictures, however, may be transmitted to Maritime Headquarters (MHQ).

In summary, the computing and communications systems of the RAAF are disparate, poorly connected, and inadequately serviced. This inadequate infrastructure has arisen through the failure to acquire and orient these systems coherently towards achieving the main objective of the RAAF, namely, strategic and tactical air operations.

Most of the efforts and resources of RAAF CSS has been towards sensor fusion (NADACS) and data fusion (AHQTS, AHQLAN) tasks. There has been a limited attempt at information fusion (BACSS) and at present, knowledge fusion does not receive any support at all.

1.6. The Wider CSS Context

Several command support and intelligence support systems are planned and have been implemented within the Department and the ADF (see Figure 2). Reference 3 attempts to integrate these projects under a common vision:

"To provide ADF Commanders with an overview of operations and the ability to focus on detail when required."

For intelligence support, DIO will have ADFDIS providing strategic intelligence and analytical tools to intelligence cells at strategic and operational level headquarters.

The Joint Command Support Environment plans to develop computer support for situation awareness, office automation, briefing, information management, planning, decision-making, and training. The initial headquarters planned for the JCSE are HQADF and HQNORCOM.

At the operational level, each service will have projects which address the need for further computer support to the command and control functions. The physical co-location of the single service operational headquarters appears certain by the end of the century. The issue of computer support for a central co-located headquarters, however, has been addressed within the Department only recently.

Each of the single services have initiatives for providing their own tactical command and control systems. Army has spent many years defining its requirements for a Command Support System. AUSTACCS, in the near future, will provide the basic elements of a Command Support System for its land operations. Navy has procured their fleet Command Support System from overseas, a system which has provided them with interoperability with other allied nations. Future initiatives for the maritime area would suggest that similar and more advanced technologies will be produced through our indigenous capabilities. For the RAAF CSS to operate in a joint environment, the minimum level of interoperability is data fusion. That is, the RAAF CSS must be capable of sharing all types of data with the CSSs of the other services. To perform joint operations, however, the minimum level of interoperability required for the RAAF CSS is information fusion, that is, the RAAF CSS must be capable of sharing and integrating all the elements required to perform missions. As well, the role of the RAAF CSS at a joint headquarters must be supported by its capability to perform knowledge fusion, that is, the RAAF CSS must be capable of sharing and integrating all the knowledge required to plan and perform in joint operations.

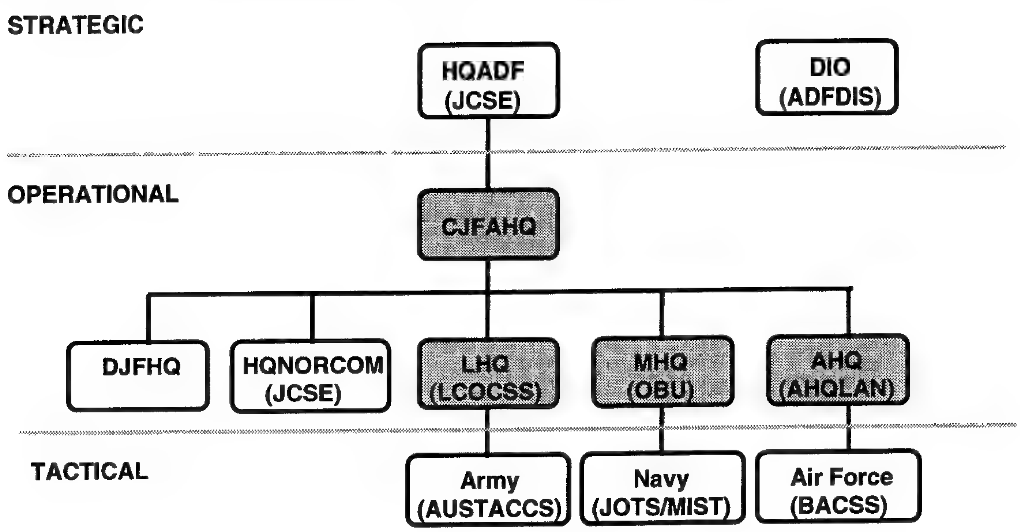

Figure 2. *Command support and intelligence support within the Department and the ADF. Shaded boxes represent those hierarchical elements which may be included in a co-located joint headquarters.*

1.7. Approaches to Broad Capabilities

The ADF Command and Control Information Systems Plan (Reference 3) was developed with an appreciation that the problem domain is ever dynamic and:

"The user requirement for a CSS is never static, and will always evolve with experience."

This document was not planned as a user requirement specification—this is because the user requirements for RAAF CSSs will change from the time this document was written until the ACSS becomes operational.

Most user requirement documents attempt to reduce the task to its functional and non-functional requirements. A simple functional classification, however, often fails to capture many of the complexities of Command Support Systems, and the arbitrary reduction into functional and non-functional requirements often fails to consider the rapid progress of modern technologies.

Even though user requirements change as they are dependent on current situations, along with the styles, personal preferences and experiences of the individual commanders, the general requirements or broad capabilities of CSSs can be defined.

The main functions of a CSS, as highlighted by Reference 3, are to:

- Display an integrated *Common Situation Picture*. This may be described as the situation monitoring and awareness function which tracks the statuses of friendly, enemy and neutral forces, and which locates events of military or political significance in their geographical and other contexts.
- Disseminate data and information to other headquarters and authorised organisations. This is referred to as an information management and communications function for message and data transmission or reception. It may be supplemented also by an ability to store messages and data and to retrieve them rapidly as required.
- Assist planning and decision-making. Planning aids are tools which enable commanders to perform appreciations of situations and to plan the allocation of necessary assets to meet emerging threats.
- Facilitate briefings to RAAF commanders and other agencies, namely, the ability to display current situations, assessments and plans in a manner suited to RAAF, other ADF, Government and civil personnel.
- Provide simulation for staff training, that is, the ability to operate the system using information from computer-generated, rather than real, events and actions.
- Provide office automation, comprising word processing, spreadsheet, presentation and e-mail applications.

The broad capabilities of Command Support Systems have been defined in such a way that the user requirements themselves can change.

When defining the broad capabilities required of future RAAF Command Support Systems, DSTO has emphasised the architecture necessary to support the main purpose of the organisation—in this case the RAAF's strategic and tactical air operations—all within an environment that is dynamic and changing constantly. Flexible systems are required which support individual and team-based decision-making in distributed organisations and in widely different situations.

This approach has been adopted for several reasons:

(i) Computing hardware manufacturers have made a firm commitment to open systems and common standards, with the result that the cost of hardware is falling rapidly.

(ii) In communications, increased capacities have become available through efficient switching and bandwidth allocations, with the result that the cost of communications is also falling rapidly;

(iii) The major challenges facing organisations in the future will be developing smart applications capable of using communications and IS infrastructures;

(iv) Although basic requirements can be defined, user requirements are changing, creating a demand for environments that supports such changes; and

(v) It is users, not professional software developments, who are driving the development of smarter applications.

2. Overview of Capabilities Identified

Command Support System capabilities as distinct from IS implementation requirements, have been emphasised. Separating such Command Support System issues from IS implementation issues highlights the precise business supported by a CSS. It enables effort to be concentrated on what is specific to RAAF CSSs, for example, rather than on logistics or Army CSSs.

2.1. CSS Capabilities

Three important concepts describe the broad capabilities required of CSSs.

CSS Concept 1

Commanders generally operate in environments characterised by incomplete, inconsistent, uncertain and equivocal information. As well, the information requirements of individual commanders depend on their individual backgrounds and the situations at hand. The information requirements of individuals in given situations cannot be pre-specified completely. This is why it is important for commanders to tailor and vary their information requirements as situations change.

CSS Concept 2

The work tasks may be performed by *agents* which have the necessary knowledge of tasks, the required information, the tools to manipulate the information, and the information suitably formatted to facilitate its use in performing the tasks. Tools, tasks, information and representations change over time, however, and hence users also need the means to transform their tools, representations, information and tasks to meet changing requirements in situations which are themselves transforming.

CSS Concept 3

Typical commanders operate in computer environments which represent the purpose and functions of their organisations, their access to tools, information, tasks and views—all provided in an organisational context. Commanders also need to complete their tasks independently of any IS implementation considerations.

The broad capabilities required by a CSS at the highest level can be stated in concise terms.

- A CSS should support users in performing their key business processes of command and control.
- A CSS should facilitate the organisation in executing its operational missions.
- A CSS should support users in performing their roles in organisational and situational contexts.
- A CSS should support formal and informal flows of information and knowledge.
- A CSS should support the workings of individuals, groups and organisations.
- A CSS should provide an environment which develops, changes and tailors its user requirements over time.

2.2. IS Capabilities

Two important concepts describe the broad capabilities required of ISs.

IS Concept 1

Governments and industry have addressed the wide issue of IS integration and interoperation, and standards have emerged which enable ISs to interoperate and to provide the functionality required by users. ISs which can interoperate will provide all non-business-specific support.

IS Concept 2

Users will tailor and develop applications through what is termed a *distributed object management system*. All tasks, views, information and tools therein are regarded and processed as objects which can be stored on a number of computers. The distributed object management system retrieves tasks, tools, information and views—transparently for users. Users are aware that the global or virtual object space contains the tools, views, information and tasks which are required, retrieved, and processed by them.

The broad capabilities required by an IS can be stated at the highest level in a few concise statements.

- IS interoperation permits ISs to co-operate when executing tasks jointly.
- IS development should follow an object-oriented, open, standards-based approach to systems.
- IS development should include middleware to provide a high-level platform-independent environment for the development, maintenance, and run-time support of distributed applications.
- IS development should adopt the architectures and standards necessary for distributed object management.

3. User Organisation

The current user organisation is documented extensively in Reference 4, and an overview only will be given here.

The focus of ACSS is the command chain from ACAUST to OCWG to COSQN. The important role of the SADC chain of command, and the roles of Group Commanders needs to be stated concisely. Nor will all command chains necessarily always include Commanders—only those with the assets required to meet current threats are required. As well, the actual personnel numbers in the organisation and the relative numbers required will change constantly as the threat ebbs and flows in the transitions between peacetime and wartime activities. The roles performed by those in the command chain and their support staff will vary markedly as situations change. The number of people performing key roles will also change in order to meet varying demands.

Identifying the users of future systems is often seen as essential to user requirement specifications. Users of systems need to be represented in more than just the requirement specifications. As operators of software alone, they are an integral part of any Command Support System.

The typical roles which users perform in headquarters are those which are required regularly. Threat situations may arise, however, which necessitate that further expertise is brought into the headquarters—such short-term expertise, for example, may be gathered through informal communication with other headquarters. Longer-term expertise may be acquired through defining and creating special roles within headquarters and fulfilling the requirements of those new roles.

Roles are refined and changed over time. The users of future systems should be able to adapt and change their roles within their organisations, therefore, to meet the changing demands of their intentions and enterprises.

ACSS should provide software which represents users in terms of their roles in their organisations. The specification of these roles, which are changing and are not fixed, should be a dynamic process. As these roles change, an ACSS should have the flexibility to accommodate these changes.

As part of Task Air 93/025, the various roles performed within the RAAF Command and Control system were identified and analysed. For each such role, the tasks, the tools, the information and the necessary representation of such information were all specified. Many advantages are gained from such representations; for example, the flexibility to define pre-specified routine tasks and to perform additional tasks concurrently to meet unusual situations can be designed into such command and control systems. For a more in-depth discussion, see Reference 4.

4. Command Support System and Information System Characteristics

Developing the next-generation RAAF Command Support System presents many challenges. For example, the procuring of a turn-key system to enhance current capabilities is no longer regarded as feasible or economically viable. As there has already been some progress in providing information technology support to command and control, a clear path has to be set for the migration from the current legacy to future capabilities.

The Command Support Systems of the single services are neither monolithic nor isolated. Instead, they comprise many of the building blocks of a wider Defence Force network. Interoperability of computer systems through military message systems is no longer sufficient to support such a diversity of new media, such a quantity of information or so many complex networks operating concurrently in future ISs. Many of our current concepts of interoperability are simplistic and require urgent review.

Nor can the current heavy investment in information technology continue without a clear statement of a business case. Information technologies need to be aligned more closely to the main businesses of organisations so that their assets and leverage can be maximised. The main business of the RAAF is expressed in the statement (reference 5):

"To conduct effective strategic and tactical air operations as an independent force, or part of a joint or combined force, in the pursuit of Australia's defence and national interests."

The key concept throughout this Section is that a central IS architecture can provide the essential computing and communications services for a RAAF CSS. Extending the actual CSS architecture are the computing applications and services which support the main business processes of the RAAF.

4.1. CSSs and ISs

At present the RAAF has several computer systems which support specialist areas. For example, CAMM2 supports aircraft maintenance and the AHQTS, and air tasking. These systems have developed in isolation, however. Several use proprietary hardware and software applications, and essentially "stove-pipe" information to terminals. It is noted that the business applications of the system have become entwined with the IS aspects, which places enormous stresses on users who find they must be aware of each IS they use in order to benefit from them.

AHQLAN has attempted to make existing systems appear less dysfunctional by enabling users to access several systems from single workstations. Users have to learn how to operate a number of very different ISs, however, and have found they spend less time on performing actual work.

Figure 3 presents the current position in terms of IS developments and how we presently view a CSS, logistics system, maintenance system and other computing systems. For the RAAF, a CSS is a collection of ISs which provide very limited support

to users. The reasons for this limited support have resided in the challenges of bringing about IS integration and interoperation and in the difficulties of separating command support applications development from IS implementation.

The development of computer systems for logistics and maintenance has been more successful than that for Command Support Systems. This is attributed to the clearer definitions of information space for these functions, and the fact that the tasks which the system supports are relatively straightforward, well defined, and often highly repetitive and unvarying from one situation to another.

The information spaces of Command Support Systems, however, are more complex and abstract, hence poorly defined. Some aspects of command support are repetitive and do not demonstrate much variation from situation to situation. CSS is often confronted with rapidly changing situations, limited information about threats to be met, along with internal constraints such as shortages of replacement parts for aircraft. Essentially, command and control is the system to enable the reorganisation of one's forces in the face of emerging threats. If the assessment of the threat or current force capability and sustainability is incorrect, however, then command and control has failed.

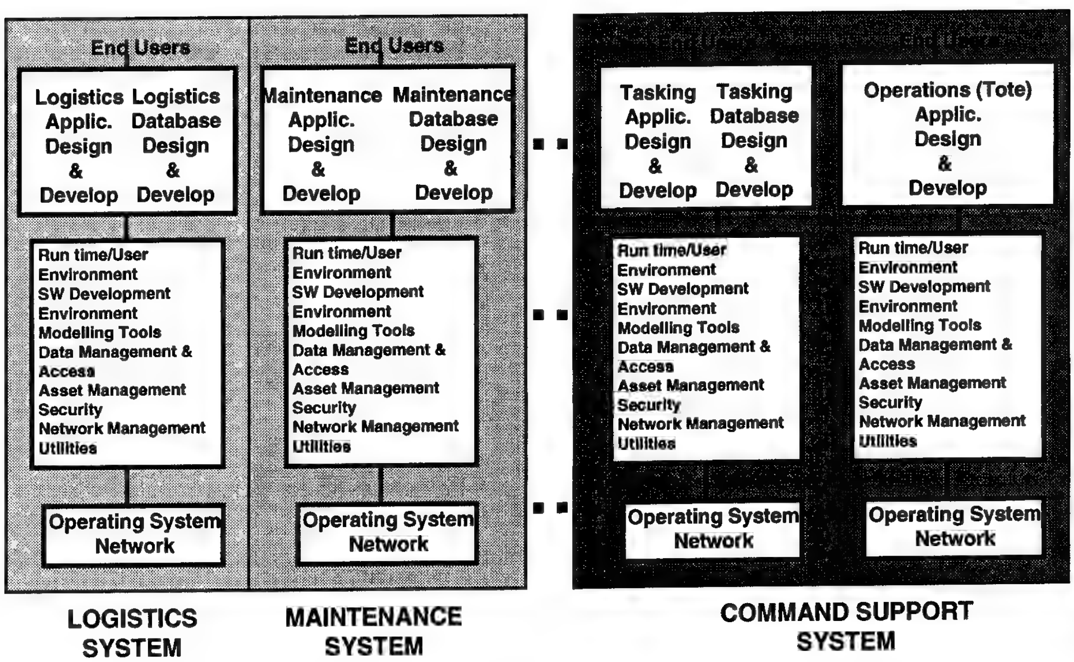

Figure 3. *Characteristics of current computer system development—stove-piped computer systems which do not separate business applications from IS implementation.*

On the principle that the application of knowledge is itself a form of knowledge, a Command Support System requires not only access to information on emerging situations but also access to knowledge which is capable of interpreting said information intelligently. Currently this knowledge is provided by people within the command chain whose rapid informal communication of knowledge, therefore, is vital

to the operation of command and control. In the future, such knowledge may be stored within the computer itself as smarter applications.

IS integration and interoperation has been addressed widely by governments and industry. Standards are emerging which will enable ISs to collaborate and interoperate to provide the functionality which users require. For example, all non-business-specific support will be provided by ISs capable of interoperating—a development with several important consequences:

(i) Business areas with poorly-defined information spaces can access systems on an as-required basis;

(ii) End users will not have to know which computer systems they are using;

(iii) Applications can be developed independently of individual IS implementation details; and

(iv) The business aspects of organisations can be separated from the IS implementation aspects.

Figure 4 shows how IS interoperation offers a different perspective of Command Support Systems. Embracing the ideal of ISs interoperation, for example, allows us to view Command Support Systems separately from the generic aspects of ISs. This maintains the focus on the real purpose of the system—the business of the organisation.

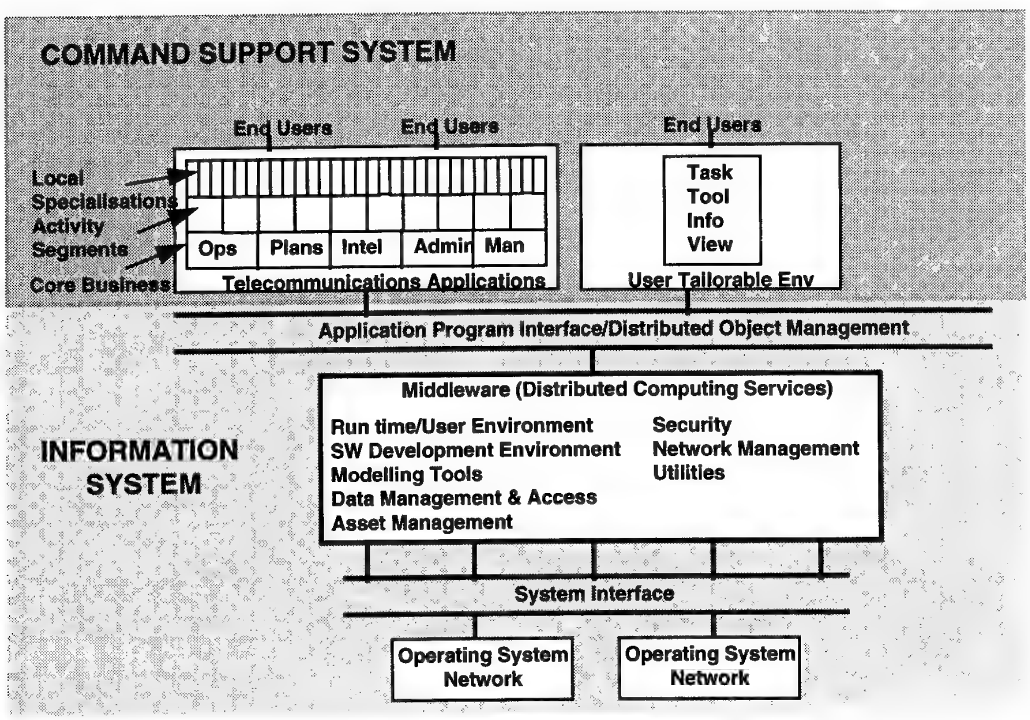

Figure 4. *Characteristics of future computer systems—business support is independent of IS implementation.*

4.2. Concepts for RAAF Command and Control Application Development

The general approach necessary for command support to adopt interoperable IS principles which permits end users to tailor and change their requirements are shown in Figure 5. Central to the overall concept are intelligent agents or people capable of performing one or more roles in organisations. In order to complete their tasks, intelligent agents require information, tools to manipulate that information, and knowledge of their tasks to be performed individually or as members of teams. Given such tasks, the information also needs to be represented clearly for its maximum and rapid comprehension.

In a world of interoperable ISs, end users will face huge spaces of information, tools, tasks and views. To maximise their use of such spaces, both information-push and user-pull techniques will be required.

Traditional computer systems were built on the basis that information is pushed to the user. Information flows were designed and implemented so that information was received by the people suitably concerned at the right time. Such an approach has been adequate during standard situations, but has not assisted users to cope with often threatening changes in their environments.

User-pull has been identified as an answer to assisting users to find the information, tools, tasks and views necessary for dealing with new rapidly-evolving situations. User-pull, however, is not as straightforward as it first appears. A question is: How do users learn what they will need to know and, more importantly, where and how to find out what they need to know? Much of this work could be carried out co-operating through ISs wherein users' inquiries are processed co-operatively and efficiently by users at often disparate locations. As well, users may want to navigate efficiently through the support system to determine the availability of information, tools, tasks, and views, as they perform their roles.

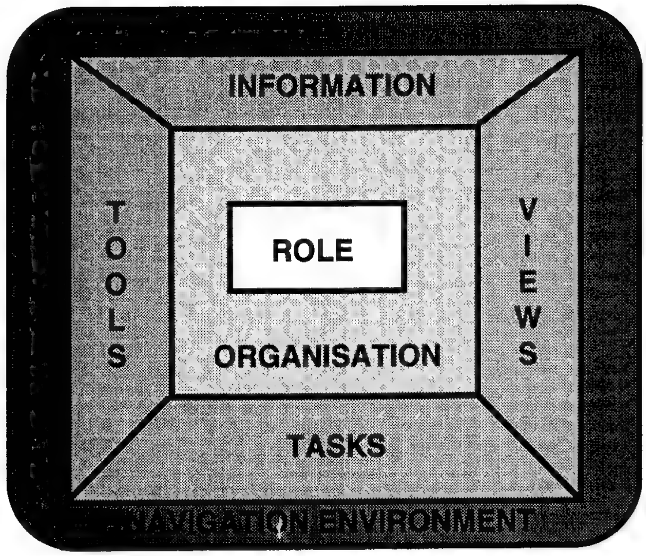

Figure 5. End user concepts for RAAF Command and Control development.

Achieving a balance between information-push and user-pull is central to designing successful systems. The information-push aspect of the system should permit changes—the information regarding even standard situations requires alteration from time-to-time. Information-push in an interoperable environment would be supported through the roles which users adopt and perform. Roles would be defined which specify the tasks, the information, the tools and the views which users need to integrate and operate in order to fulfil such roles. However, such definitions could be flexible and modified by users as new information becomes available and modifies such roles as required.

A starting point for the information, tasks and tools required by the RAAF Command Support System has been defined in the publication entitled *RAAF Command and Control: An Organisational Analysis Perspective* (see reference 4). For ACSS, several tools can be identified which may be classified broadly according to the categories of *distributed decision-making, situation awareness, situation assessment and planning* and *training*.

4.2.1. Distributed Decision-making Tools

Distributed decision-making tools address such questions as: How is expertise or special knowledge to be integrated, from users and personnel who are geographically-separated, and brought to bear when making decisions? How is a give-and-take environment for discussion and argument achieved for making decisions in which participants are not physically co-located? How is a real-time shared information space created for physically-separated personnel? How are team work and collaborative activities to be encouraged? How can common situation and status pictures be provided for groups separated in time and space?

The tools listed below enable a system to be established and maintained so that it can manage the organisation and its workflows and permit users to work in ways that are collaborative and dynamic. The system also helps users to find the information, the tools and the expertise which they need to meet evolving situations for the first time.

- The *Organisational Tool* is provided to create, maintain and update the organisation. It can also define the basic activities of the organisation, its structure, and its available resources. Commanders' goals can be set, priorities allocated, strategies defined, workflow models prepared, feedback loops set in place, assets registered, and navigation tools activated.
- The *Function Tool* can create, maintain and update functions based on an evolving organisational framework. The Function Tool is used to define tasks, information, tools, views, to design basic workflow models, to set feedback loops, and to register all properties with the Navigation Tool.
- The *Organisation Unit Tool* creates, maintains and updates the organisation units based on the organisation framework. The Organisation Unit Tool allocates the tasks and intelligent agents to fulfil the roles set by the organisational framework. It develops the structure of the organisation framework such that new organisation units and functional cells are added, new workflow models designed, added and maintained, feedback loops set, and new tasks, information, tools and roles set, obtained and defined within the functional cells as all these are required, and all properties are registered with the navigation tool.
- The *Role Tool* maintains and updates the workflows based on the evolving organisation unit framework. It uses the organisation unit framework to allocate resources and tasks. It adds and maintains workflow models and feedback loops, and registers all properties with the navigation tool.
- The *Navigation Tool* creates, maintains and updates the overall properties of the system. It is used to guide users through the organisation, to observe its structures, and the roles performed, along with the allocation of information, tools and tasks.
- The *Workflow Tools* creates, maintains and updates the flows of information and work through the organisation. This tool integrates the tasks performed by different roles, and associates the timing and relationships between task performances.
- The *Meeting Tool* generates agendas, records the proceedings and decisions of meetings, and allocates resulting actions.
- The *Briefing Tool* generates and presents briefing material in the most suitable media.
- The *Communication Tool* generates, maintains and updates messages. It may be used to format messages or personal communications. In this way it supports interactive, multimedia conversations as well as simplex communications.
- The *Desktop Tool* generates, maintains and updates individual information, tools, tasks and views.

- The *Sharing Tool* stores and displays information, tools and views common to groups of users. Such stores and displays, for example, include shared workspaces and electronic blackboards.
- The *Document Tool* generates, maintains and updates document-based information sources such as reports, directives, and plans.

4.2.2. Situation Awareness Tools

Situation awareness tools are designed to provide users with information and awarenesses in response to questions which may be classified in four main categories:

(i) *Surveillance awareness*. Where are my sensors? What is their availability? What is their coverage? What can I see? How old is the data? What is the required sampling rate for each battlefield area, target type, and sensor type?

(ii) *Enemy awareness*. Who is the enemy? Where is the enemy? What is the enemy doing? What are they trying to make me think they are doing? What is their probable intent? What are their capabilities and constraints? What do their doctrine and tactics dictate? What is the weather, terrain, logistics? What lines of communication exist?

(iii) *Own force awareness*. Where are my own forces? What are their current strengths and vulnerabilities? What are their current missions? Can they be diverted? What about weather and terrain? What lines of communication exist? Is electronic warfare likely?

(iv) *Specialist capabilities awareness*. What about special capabilities and employment of UAVs, space, remote imagery, JORN?

Several tools, which may be classified as situation awareness tools, are also required.

- The *Mapping Tool* displays cartographic information. This includes the ability to select geographical areas, along with the capability to zoom in, zoom out, pan up, down, left and right on a map capable of displaying centres of population, roads, railways, airports, ports, political boundaries, rivers, terrain, detailed topographies, and weather.
- The *Asset Distribution Tool* displays the locations of own, enemy and neutral force assets, and assessments of likely unknown bases, aircraft and radar installations.
- The *Asset Capability Tool* displays the capabilities of aircraft, bases, sensors and organisations.
- The *Airspace Management Tool* displays the positions of CAP, tankers and AEW&C, sectors, ADIZ, beyond visual range zones, missile engagement zones, and safe corridors.
- The *Data Fusion Tool* correlates and associates data, in particular sensor data, to enrich views and interpretations of current events.
- The *Information Fusion Tool* correlates and associates data and provides an enriched interpretation of current events, particularly in the areas of multi-sensor, plans and intelligence data.

- The *ROE Tool* selects, generates, maintains and updates the current and possible Rules of Engagement.
- The *Log Tool* creates, maintains and updates reports of events as they develop. The Log Tool permits events to be sorted by date, time, place and location or by other user-defined properties.
- The *History Tool* places events in chronological order.
- The *Time Tool* displays situation information at specified points in time, presents the flows of assets over specified periods of time, and offers stepped views through situations in pre-defined intervals.
- The *Pattern Recognition Tool* absorbs data on, and notices patterns, trends, and unusual occurrences in data on a wide range of information sources including location of assets, emitter frequencies and numbers, tracks, situations and equipment failures.
- The *Availability Tool* generates, maintains and updates the allocation and current usage of resources.
- The *Board Tool* generates, maintains and updates tabular information. It is used to activate and direct alert information, aircrew, maintenance, tasking, flying programs, and exercise programs.

4.2.3. Situation Assessment and Planning Tools

Situation assessment and planning tools are provided to answer questions such as What can the enemy do next? What are the constraints over the enemy? What can I do next? What are the constraints over me? How much time do I have? What are my risks? What are the enemy's risks? What are my real options? What if I do this? What if the enemy does that? How fast? How far?

- The *Change Tool* detects and highlights the differences between the situation information and expectations.
- The *Plan Activities Tool* generates, maintains and updates the static graphical representation of activities.
- The *Plan Execution Tool* generates, maintains and updates the dynamic representation of activities.
- The *Time and Space Tool* calculates the spatial and temporal relationships between items of nominated information.
- The *Air Space Control Planning Tool* assesses best routes, manages air space, and deconflicts missions.
- The *Force Allocation Tool* allocates possible assets to planned activities.
- The *Target Assignment Tool* assigns aircraft to targets and specifies the destruction requirements.
- The *Weapon Assignment Tool* allocates weapons to aircraft.
- The *Communications Planning Tool* allocates bandwidths and channels.

- The *Electronic Warfare Planning Tool* allocates tasks and their frequencies of completion.
- The *Simulation Tool* plans real time and fast simulation activities.
- The *Plan Comparison Tool* detects and highlights different planning options.
- The *Sustainability Tool* generates, maintains, updates, and projects the use of resources.

The essential activity of situation assessment and planning is the direction and control of forces. Force direction and control often requires the modification, replanning and restructuring of missions, along with any necessary retargetting and rescheduling of aircraft—activities inherent to the development of situation assessment and planning tools.

4.2.4. Training

A Command Support System should support both peacetime and contingency operations, both of which require training in the use of software. Contingency operations are more exacting, however, and should be exercised frequently.

These training tools are designed to exercise individual and team-based decision-making through a series of exercises which increase the load and sophistication of duress for operators and decision-makers. Such training exercises improve the qualities of workflows devised and tasks allocated for personnel and equipment by trialing "what if" scenarios. The Scenario Generation Tool, which scripts such exercises, can combine both real-world and exercise data. In turn, the Scenario Execution Tool is capable of freezing exercise data so that it may be re-examined and assessed, so that responses to real-time information can be improved.

4.3. A Master Architecture

A future Command Support System for the RAAF must be developed within the confines of sound technical and domain frameworks. A master architecture provides a framework in which policies, concepts and implementation issues can be integrated. A domain framework is presented reference 4. A technical framework is presented in Section 4.4 of this document.

Figure 6 shows a master architecture composed of the following 6 levels:

- The *Global Level* addresses IS issues which apply worldwide, such as industry standards and the use of commercial-off-the-shelf (COTS) products and services. Use and/or tailoring of COTS products is seen as cost-effective as it reuses and builds upon hard-earned expertise. However, relatively few COTS products and services specifically meet the needs of Command Support Systems. The integration and updating of COTS products, therefore, could prove problematic.
- The *System Level* provides strategic and corporate guidance for the development of Command Support Systems. As well it provides information storage, systems interoperation and security. Corporate ISs guidance includes

such initiatives as the Government Open Systems Interconnection Profile (GOSIP) for command and control along with any specialisations required for RAAF interconnection.

- The *Mission Level* aspects are those which address the business of the organisation. Business re-engineering is the "radical redesign of existing business processes to achieve efficiency and better services". The re-engineering of business process, therefore, flows from the identification of the central business processes of the organisation. For RAAF Command and Control these are: operations, management, logistics, intelligence, liaison, plans and administration.
- It is useful to relate the main business processes of an organisation to the key activities performed by the enterprise. For example, performance logistics means little unless the purpose of the logistics is included—in the case of the RAAF, management for air defence operations.

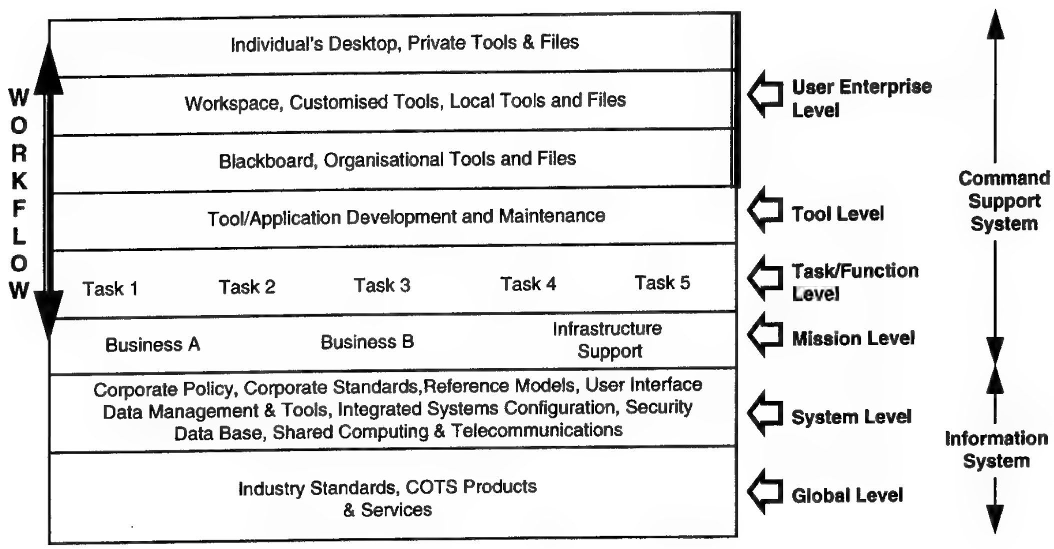

Figure 6. A master architecture for RAAF IS and CSS development.

- The *Task/Function Level* addresses the automation of business processes. The re-engineering of business processes can be achieved by simple functional decomposition. Functions are mapped from the existing business environment onto computer functions or new ISs. Another way to represent business processes is through the use of tasks. Tasks can range from simple physical tasks to complex cognitive ones. Usually they are performed in some time sequence, some with more complex representations which result in parallel branching of actions and which present associated requirements for synchronisation planning. Task performance and business processes also change over time, which means that future systems should be able to represent tasks and functions explicitly so that these may be developed

dynamically, possibly even radically, as tasks are tailored to meet changing situations.

- The *Tool Level* addresses and monitors the support provided through the automation of tasks. This level is sometimes called the *application level*. An application is usually a software program or suite of programs developed to process particular functions within organisations. Applications are rarely modified easily, so that it is the use of tools rather than of applications in future ISs which will assist users to identify the true constituents of software applications. At present, such applications perform relatively simple tasks. For example the tool of a spreadsheet application provides mathematical operations in a two-dimensional data structure. Information is added by users. In more complex applications, the tasks, the tools and the information is embedded closely so that the software application is used as a whole.

  Workflow is a new term in the computing industry. Workflow diagrams are used to represent task structures explicitly, with each task in the workflow then allocated by roles in the organisation, and a person or persons allocated to performing the role. In completing the tasks, operators may require one or more tools along with sets of information provided from various databases.

  Increasingly sophisticated software is emerging for workflow management. Such software is capable of delivering the required information and tools to the individual users' desktops for processing.

  Workflow software explicitly represents tasks, tools, information and roles. Each of the components are defined dynamically so that users can change them. It is even possible for users to change the sequences in which tasks are performed, in response to changing situations and personal preferences.

  At present the representation of tasks in workflow diagrams is superficial. However, such diagrams enable enterprise-wide operations to be co-ordinated—providing useful support for standard operating procedures.

  The use of workflow diagrams has focused functions within and across organisations. However, the concept of workflow is applicable equally to individuals performing cognitive tasks. For example, to plan air tasking, an OPSO can perform several cognitive tasks—whether the tasks are performed depends on the situation at hand and the OPSO's level of experience.

- The *User Enterprise Level* can be viewed as three separate levels which address the needs of individuals, groups and organisations.

  Historically, computer support has assisted individuals to perform relatively simple tasks, as it is individuals who are the points-of-work within command and control systems and whose needs must be satisfied. For example, individuals require their own spaces such as desktops in which tasks can be performed without interruption or display of the results to others. The desktops of individuals are regarded as private places wherein their customised tools are available, and information can be filed via individuals' own systems.

  Desktops are the points at which individuals fulfil their roles within the Command Support System. If the concept of workflow is adopted, then the necessary tools and information are delivered to the desktops concerned for individuals to fulfil their roles. The information for a role is formatted or

represented by what is called a *view*. For example, air tasking information can be viewed differently according to whether an individual's role is the OPSO at AHQ, OPSO at wing level or OPSO at squadron level.

Work or tasks are performed by agents which have the necessary knowledge, information, and tools to manipulate that information, and the information in a format which facilitates the use of the tools to perform the task. However, tools, tasks, information and representations all change together over time. Users will also need a means to transform their own and others' tools, representations, information and tasks.

The computer industry has only just begun to recognise the paramount importance of providing support to individuals and groups of workers. Software tools to support group work are known as *Groupware*. In some respects, ASMA was a forerunner of today's groupware products, as it enabled groups of people to communicate and collaborate to solve problems. Important information was entered on to totes so that it could be shared with other headquarters and dialogues developed.

Groupware technology is an extension of electronic mail and operates from desktop-to-desktop. Groups of people are able to see the documents generated by their members—documents may be in any media, even multimedia.

Groups may share, or be separated by, time and space. For example, in the RAAF, typical roles are executed by people who are part of functional cells such as operations or plans. To fulfil their roles in such functional cells, individuals often require a common understanding of the situation or problem, or must be kept informed as information is received by, or generated from within, functional cells. In groups, information is shared, tasks allocated, and tools are necessary. Workspaces may be provided for groups where all information, tasks and tools are represented and the current states of the situation and work performed are displayed. Workflows within functional cells may be represented explicitly and managed in the cells' workspaces.

Ensuring a common understanding across several headquarters and functional cells is essential for organisational success. For example, within HQ81 Wing it is essential that everyone is kept informed of current situations in terms of own and enemy forces—in particular, 81 Wing assets. This requires that common information and tools are shared across organisational units.

4.4. Strategies for IS Interoperation

It is widely accepted that information technology support to command and control requires mechanisms for interoperability. Such interoperability between Command Support Systems in the ADF and between our allies is achieved through a common message format. The message system, ADFORMS features many preformatted message types for identified situations. ADFORMS Interface Machinery is soon to provide support for machine formatting of ADFORM messages. Users require a wide number of different message types along with the abilities to generate and refine messages, if interoperability is to be enhanced.

Interoperability can be classified into three levels:

(i) Connectivity where ISs can exchange messages;

(ii) Interoperability where ISs exchange messages to request and receive services from each other, i.e. they use other users' functionalities; and

(iii) Co-operative ISs where ISs interoperate to execute tasks jointly.

Achieving co-operative ISs will provide users with a Global (Virtual) Object Space, which contains any information, tools, and tasks required by users. The objects required by users are unlikely to be stored in a single system, however, and for users to retrieve them will require the co-operation of agents who know about ISs, to process transactions.

The information technology community is aware of the impossibility of integrating all ISs. Integration would imply the global naming of data items along with consistency throughout all ISs—which is clearly impossible. Integration occurs at the component level where components could be whole ISs. Component-oriented integration is useful as it models the system as a network of interacting components, it avoids standardising on any single architecture, and it enables components to be defined independently so that they can be reused in different architectural configurations to meet requirements as they evolve.

4.4.1. Architectural Characteristics Necessary for Interoperability

To achieve interoperability, developers must follow an object-oriented, open, standards-based approach to systems.

An object-oriented paradigm supports the use of messages to objects. Message can be sent to objects whose abilities to receive and act on them depends only on the interface of the componentry. Locally-defined procedures for objects allow components to respond independently to messages. Procedures may be changed, independently and transparently, so long as such interfaces are maintained. An object-oriented approach is compatible with three of the important characteristics required of interoperable ISs: heterogeneity, autonomy and distribution.

Heterogeneity means that not all systems need be alike. An object-oriented approach, in fact, supports heterogeneity by focusing on the sending of messages to component interfaces rather than on the internal architecture of systems.

Object-orientation also supports autonomy, which permits all systems in networks to respond in their own ways, by allowing procedures to be defined and changed locally.

From a strategic point-of-view, distributed systems are essential in terms of efficiency of use, reliability and survivability of computer resources. Object-oriented techniques enable multiple processes to be distributed across computer networks.

To achieve interoperable ISs requires an open, standards-based, approach to systems. Such an approach:

(i) facilitates extendability and system evolution;

(ii) accommodates heterogeneity, autonomy and distribution;

(iii) avoids duplication of effort by combining technologies developed by industry consortia and standards bodies; and

(iv) encourages reuse of resources.

To enable organisations to focus their efforts towards tailoring their software towards their unique requirements, IS implementation has tended to standardise aspects which are common across applications, and in a vendor-independent manner. Services common to applications and located between the applications and the operating systems are known as *middleware*. The aim of middleware is to provide a high-level, platform-independent environment for the development, maintenance, and run-time support of distributed applications (see Figure 7).

Middleware provides many of the building blocks for the development of heterogeneous, autonomous, and distributed systems. Among the distributed computing services provided by middleware are user interface components, distributed computing environments, software development environments for computer-aided software engineering, and modelling tools, along with tools for data management and access, asset management, computer network management, telecommunications network management, and security.

Development of applications on top of middleware services requires an architecture which allows distributed applications to be integrated. This is the aim of the Common Object Request Broker Architecture (CORBA) put together by the Object Management Group. Applications specific to particular organisations such as RAAF Command and Control are able to call on information and tools from global object spaces, including military-specific object spaces for security reasons, and can use services provided by CORBA which enable distributed object management.

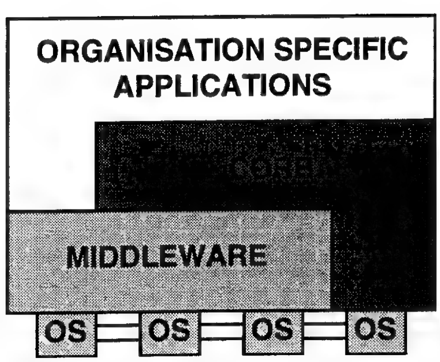

Figure 7. Application construction and maintenance services for interoperable ISs (OS = operating system, CORBA = Common Object Request Broker Architecture).

Middleware and distributed object management systems permit end users to develop applications to support their core businesses without having to know the implementation details or origins of the objects used. Object-based development of applications is shown in Figure 8. Support for the core business of RAAF Command and Control such as applications for operations, planning, intelligence, administration and management are developed using an object management system. Each business application is then specialised for activity segments such as air defence, surveillance, maritime interdiction—with local specialisations for organisational units.

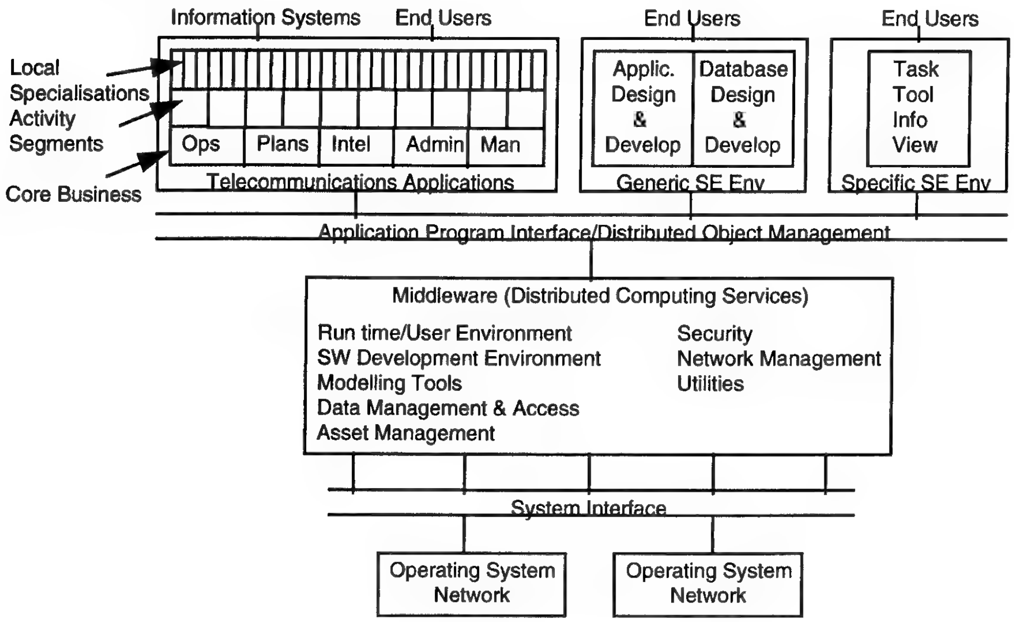

Figure 8. Open systems architecture for development of object-based applications.

Object-based applications development is ongoing in general software engineering environments where fundamental applications are developed and databases implemented—specific software engineering environments may also act as venues. These enable end-users to access and define objects which produce tools, views and applications for use by themselves, by other operators, and by groups.

4.4.2. Interoperability Requirements

ACSS users will source much of the information they require not from the ACSS itself but via electronic links to other RAAF, ADF and even commercial systems. The links most likely required are listed in Table 1. Electronic links to other systems may be established also on an as-required basis provided security restrictions remain unviolated. In this case, the electronic links are not necessarily physical point-to-point connections—for example, the use of Defence Switched Data Network will provide greater flexibility in communication. The inter-networking of future systems will enable system managers to establish and manage networks which are logical rather than physical—establishing virtual private networks.

Table 1. Organisation, system and possible information interoperability requirements

Organisation	*System*	*Possible Information*
HQADF	JCSE	From: Policy and request for information To: Status, responses and requests for policy
MHQ & Fleet	JOTS or MIST OBU	From: Status (data, text, graphics), requests and responses To: Status (data, text, graphics), requests and responses
LHQ & Units	AUSTACCS LCOCSS	From: Status (data, text, graphics), requests and responses To: Status (data, text, graphics), requests and responses
HQJFA	CCIS	From: Policy and request for information To: Status, responses and requests for policy
RAAF	AHQLAN BACSS NADACS - Air defence, air control command and control system, JORN, CAMM2 Logistic support systems	From: Sensor, operational, maintenance and logistic information To: Requests, responses
ADF	Topographic support system	Form: Natural and artificial features of specified area To: Requests for area topography
DIO	ADFDIS	From: Strategic intelligence, and current intelligence as available To: Situation reports, requests for information
Allies		From: Status (data, text and graphics) requests and responses To: Status (data, text and graphics) requests and responses
Coastwatch		From: Ship, aircraft information, requests for assistance, sensor taskings To: Requests for information, results of sensor tasking
Customs		From: Situation information and requests for assistance To: Requests for information
Civil Aviation Authority		From: Situation reports, SAR and medevac requests To: Requests for information
Bureau of Meteorology		From: Current and forecast weather for specified location To: Requests

4.5. Performance

4.5.1. CSS Performance Issues

The performance of a CSS is dependent on the complexity of the task performed, the amount of information and knowledge required, and the experience and expertise of the users. It is difficult to predict the tasks performed and users' abilities at any instant in time. Worst-and-best-case scenarios may be used to help predict possible usages.

4.5.2. IS Performance Issues

The performance of distributed systems depends largely on the effective allocation and management of resources. Where possible, large volumes of information should be processed locally, if communication lines are to be used efficiently. Distributed database transactions for text, graphics, images, geographic and video information can

be bandwidth-intensive. Where possible, the information transmitted should be change information only, and the use of locally-available tools should be maximised.

If ACSS becomes a fully interoperable IS, its response times will depend partially on the systems with which it interacts—such response times should be acceptable to the ACSS.

The storage media for electronic information has become more powerful and cheaper. At the same time, the type of information that can be stored in electronic media has become more diverse, and of vast capacities. ACSS will be required to store video, image, graphics, and sound, along with text.

4.6. Security

4.6.1. CSS Security Issues

CSS security needs to provide privacy and trust to all aspects of user organisations. Security ensures that information limited by any *need to know* basis is accessed only by those with the right to do so. The use of roles in defining information requirements limits those who can access certain information and tools in their object spaces, on other's desktops, and through their workspaces and blackboards. The use of views restricts how information is represented, while tools limit the ways in which users can manipulate the information.

Request to alter access to information can be made only by requesting the authority from the author or from specified authorities.

4.6.2. IS Security Issues

Ultimately ACSS should be able to handle all information ranging from unclassified to Top Secret codeword. Staff may be required to work with mixed security systems as an interim arrangement until multi-level secure systems become available.

Most of the information handled by ACSS is classified at *Secret* or below. Special intelligence information may be separated from general service information by the use of trusted one-way gateways.

ACSS may require networks operating at *TS codeword, Secret (AUSTEO) system high,* and *Restricted.* It may also require access to systems operating at various security levels.

Current initiatives in the development of secure multi-level environments rest with compartmented mode workstations and trusted gateways linking system high networks. Compartmented mode workstations require accreditation and will always be one to two years behind the state-of-the-art as the accreditation process freezes the technologies.

Trusted gateways, such as the DSTO-developed STUBS, can be fitted retrospectively to systems and offer greater flexibility than the use of compartmented mode

workstations. ACSS should also address its requirements for secure database facilities as these appear to have matured to the B1 level.

Traditionally, trusted systems have addressed operating systems and network aspects of their usage. Secure databases are a move to providing security features in other computer software. Security features may well be developed for other applications such as sharing tools, document preparation tools, and so on. ACSS should assure data integrity in terms of validated authorities for data held by the system, which should be developed in accordance with SECMAN3. As well, an automatic log of systems usage should be kept for security purposes which notes staff log-on and log-off times.

4.7. IS Availability, Reliability and Maintainability

A system failure in the middle of a key RAAF operation could have severe consequences. Therefore an operational system needs to be highly available and reliable. Availability, determined by users' access to systems, is dependent upon the number and location of workstations and on the systems' reliability, namely, its capacity to operate without significant downtime during anticipated operations. *Maintainability* is the system administrator's ability to perform routine maintenance, to make minor changes to the system, and conduct general house-keeping operations without interrupting the users during operations.

The ACSS should be designed which is highly available and reliable, which requires replication and distribution of data services, and the adoption of routine maintenance procedures which, when carried out, cause as little disruption as possible to other users.

4.8. Usability

A Command Support System must be usable, in that many key military decisions are made under stressful conditions. It is essential, therefore, that the Command Support System assists rather than hinders decision-makers by removing, rather than by placing, obstacles in the path of users. Difficult tasks performed often by users of Command Support Systems demand that the system and its results, namely, its decisions, are usable.

4.8.1. CSS Usability Issues

The general framework of usability embraces four principal components of any work situation—user, task, system and environment. Effective usability depends upon achieving a dynamic harmony between these four components.

A universal in the development of information systems is that such systems should be designed for the people who are to use them. The release of human productivity and creativity demands that products and systems are tailored to the physical and mental characteristics of their users. Environments and systems well tailored to the needs of users will be more usable than those which are not.

As a concept, *usability* is not easy to define. All too often requirements specifications use terms such as *user friendly* which can not be measured objectively. Usability may be specified and measured in terms of operational criteria such as effectiveness, learnability and attitudes. *Effectiveness* states the level of performance achieved when performing particular tasks. *Learnability* is the ease of learning or re-learning tasks, and *attitude* is the level of satisfaction which operators gain from using the system.

Specifying usability criteria for tasks performed by ACSS would require enormous effort—such an approach assumes that systems, once built, are not changed. Good usability derives from tailoring software to meet the physical and mental characteristics of its users. *Tailoring* in this instance should be interpreted as tailoring by users to meet their own physical and mental preferences in particular situations.

Tailoring is regarded widely as the setting of one or two parameters within applications. Usability of future systems also should address *radical tailoring*, that is, providing radically tailorable environments which allow users to develop their own representations of information, tasks and tools. Organisations may have set guidelines, as in paper-based systems, but users should not allow themselves to be constrained too much by them.

4.8.2. IS Usability Issues

ACSS should adopt a clear and consistent user-interface that requires a minimum of training and provides an environment in which the users can tailor tools, information and views to their own requirements.

4.9. Flexibility

That command and control needs to be flexible and adapting has been stressed many times in this paper. Command and control is very much about making rapid organisational changes to meet emerging threats. ACSS should be designed to at least mirror, if not extend, the flexibilities of manual systems where roles, responsibilities and information requirements are modified to meet the demands of rapidly changing situations.

4.9.1. CSS Issues

CSS software should permit the dynamic allocation of roles, tools, information and views, providing users with the flexibility to create and change organisational units along with their associated roles, tasks, workflows, views and information.

Users may need also to make changes to their information access rights, along with their abilities to request information from other users who may form part of the ACSS, especially in the face of unpredicted and rapidly-escalating threats.

4.9.2. IS Issues

Hardware flexibility should permit the dynamic reconfiguration of networks where necessary. For instance, the wider use of wireless technologies and intelligent networks should be investigated.

IS software flexibility is achievable through the adoption, wherever possible, of open systems standards.

4.10. Survivability

Command and control is pivotal to effective military operations, and the importance of command and control centres of operation make them worthy targets for enemies. If computer networks or communication links are damaged by hostile activities, it is imperative that their performance degrades gracefully, and that alternative services can be made available.

4.10.1. CSS Survivability Issues

CSS survivability can be achieved through the dynamic ability to reconfigure tools, tasks, information and views delivered to nodes in the command chain.

4.10.2. IS Survivability Issues

Survivability and the ability to sustain operations in the face of hostile activities may be achieved by the use of replicated and distributed IS architectures. Such architectures provide greater robustness which reduces the chance of catastrophic failure. However, the trade-off, namely the task of managing the more complex system itself, becomes more complex—a task that is starting to be addressed by the appropriate software tools.

4.11. Communications

Modern air warfare is characterised by the use of deception tactics, a high element of surprise, and rapid event times. All these factors combine to reduce the time available for considered decision-making. To alleviate the problem, the RAAF Command and Control system must be designed to provide real-time, secure communications which are highly available.

4.11.1. CSS Communications

CSS communications also address the standard procedures, protocols, and personal etiquette of communications between people inhabiting distributed locations, while commanders gain a high level of understanding of situations, problems, options, solutions and different methods for executing said solutions. Information may be communicated in the forms of text, graphics, sound and video—all these media may also communicate their information interactively or non-interactively.

4.11.2. IS Communications

The current Defence strategic communications network provides a range of secure, non-secure and survivable communication services. However, many of the services are provided by proprietary software packages, and use hardware which is inflexible, technically out-of-date, expensive to maintain and operate, and which constitutes an inefficient use of natural resources.

Studies have determined that Defence Fixed Networks can migrate to systems having standard, open, non-proprietary interfaces and protocols where possible. It is hoped that through the adoption of international standards for military communications, computing resources can be distributed more effectively and communications capacities allocated more dynamically among command centres.

To ensure that international civilian standards meet the special needs of military users, the NATO Tri-Service Group on Communications and Electronics SubGroup Nine defined eight features considered essential when using such systems in military operations. If civilian standards are deemed not to meet those set by military users, NATO will attempt to influence the ISO and ITU standards formulation to incorporate military requirements into civilian standards—military-specific standards will be developed only as a last resort. Australia is likely to adopt a similar approach.

A key consideration for ACSS is not so much the adoption of standards, but the difficulties faced in developing systems which can migrate as communications systems in step-wise increases in capacity and performance. The development of ACSS may be driven by the need to make best use of the evolving global communications infrastructure.

5. Support

5.1. Training

Modern computer software is often complex and changes rapidly, so that its mastery requires a high level of computer literacy and on-going training. Doubtless, future users of ACSS will be familiar and comfortable with operating computer systems. However, training will be needed for COTS and other special software products. A training program will be needed to achieve and maintain required skill levels. Support facilities for training will also be needed.

Training in the use of software is very different to training individuals and teams for command and control decision-making. The training facilities required for command and control exercises need also to be provided. Use of flexible scenario-generation tools which can combine live and simulated data can be used to support an advanced and highly realistic training programme.

5.2. Life Cycle Support

It is to be agreed by what means the ACSS will be procured. The present intention is for an Evolutionary Acquisition which establishes an overall framework, implements a core system, and defines any subsequent increments according to emerging needs.

Should an evolutionary rather than whole-procurement approach be adopted for the ACSS, several system environments may need to be established:

(i) A *development environment* for new software, for testing new ideas, and for investigating initial integration issues;

(ii) A *testing environment* for the detailed testing of new facilities, and for conducting system upgrades before *going live*; and

(iii) A *live environment* for 24-hour operations by RAAF personnel.

Whether these environments need to be separate, systems should also be investigated. The relationship between the training facilities, the testing and the live environments may also require special study.

The need to integrate the working relationship of procurers, industry personnel, users, and researchers much more closely has been highlighted as a potential avenue for radical reductions in the time between identification of problems and implementation of solutions. Even with evolutionary acquisition, new problems which arise will require innovative solutions from researchers. Tools for diagnosing and analysing problems should be available in the development of test and live environments.

Requirements is not a one-off assessment. New and unforeseen requirements will arise with more advanced software technologies. Often it is the computer's ability to meet the basic requirements, along with the users' changing perceptions or mental models of the requirements which are themselves changing. ACSS should provide, trial, and implement tools which express the new requirements and offer the development and trialing of possible solutions.

This paper has suggested that open, standards-based, information systems should be adopted which are interoperable, and which offer distributed object management and an effective representation of the work performed within the command and control domain. This will lead to a system that is user-dependent rather than procurement-dependent. Although the procurement process will be responsible for putting the basic building blocks in place, eventually it will be the users who will decide how the system operates best for them.

6. Summary of Broad Capabilities

1. RAAF CSS should be implemented in an environment which has clearly identified the business functions it supports.
2. RAAF CSS should support individual commanders in executing their duties. This will require the ability to tailor information, tools, tasks and views to meet their individual needs and the requirements of rapidly-evolving situations.
3. RAAF CSS should represent the organisation and its purpose.
4. RAAF CSS should represent the functional areas within the organisation and the work carried out by those areas.
5. RAAF CSS should represent the organisational units within the organisational framework and the work performed by them.
6. RAAF CSS should represent the roles performed within organisational units.

7. RAAF CSS should provides a navigation tool to enable users to navigate through the system with its multiple perspectives—in terms of its roles, tools, information, organisational units, personnel, tasks, and combinations of these.
8. RAAF CSS should support co-ordination of work through sharing tools and workflow models.
9. RAAF CSS should support the workings of individuals, groups, and the organisation.
10. RAAF CSS should support distributed decision-making.
11. RAAF CSS should support enhanced situation awareness.
12. RAAF CSS should support situation assessment and planning.
13. RAAF CSS should support training.
14. RAAF CSS should perform to the requirements of the tasks performed by users.
15. RAAF CSS should provide private areas in which individuals can tailor their tools, tasks, information, views and methods of information management to their own requirements.
16. RAAF CSS should support several levels of fusion.
17. RAAF CSS should enable users to alter the characteristics of tools, information, views and roles in order to meet their usability requirements.
18. RAAF CSS should provide flexible environments in which the organisational structures can be changed, and roles, tools, tasks, views and information re-allocated.
19. RAAF IS should be implemented so that their functions are transparent to users.
20. RAAF IS should adopt an object-oriented, open, standards-based approach to information systems.
21. RAAF IS should interoperate with other ADF, Government and civil IS.
22. RAAF IS should adopt middleware.
23. RAAF IS should support distributed object management.
24. RAAF IS should process IS messages in a timely manner.
25. RAAF IS should provide multi-level security to all information, tasks, tools and views regardless of their media.

7. Conclusions

1. This document has defined the broad capabilities required of future RAAF Command Support Systems. It recognises that broad capabilities can be specified but user requirements are subject to changes and that environments are needed to support such changes.

2. The time-line associated with developing an ACSS is unclear so that our approach has been to define broad capabilities for a CSS that are not implementation-specific and have some longevity.

3. A framework has been developed which highlights the need for four kinds of fusion within a CSS: fusions of sensor, data, information and knowledge.

4. The RAAF currently has a number of disparate systems which are poorly connected and which do not interoperate. An understanding of the IS environment required to support the broad capabilities of a RAAF CSS, however, is beginning to emerge. Adopting an open, standards-based approach to systems will provide the RAAF with the necessary flexibility to achieve IS interoperability.

5. Current RAAF systems support mainly sensor and data fusion. Few initiatives have been made in support of information and knowledge fusion. Unless knowledge fusion is achieved, a RAAF CSS will not be able to support its role at a future joint headquarters.

6. A distinction has been made between IS and CSS capabilities, which helps to separate general IS issues from specific CSS issues, and in doing so clearly establishes the difference between CSSs and other types of support systems.

7. RAAF CSS should provide support to individual commanders in situations difficult to predict. Such tailorable environments will permit maximum usability in the field.

8. Central to the operation of a RAAF CSS are intelligent agents or people who perform roles in organisations. To carry out their assigned roles and tasks, intelligent agents require information, tools to manipulate information, knowledge of the tasks to be performed by individuals and teams, and all of the information presented for maximum comprehension.

9. The tasks, tools, information and views required by individuals will change as operating environments change. Also required, therefore, is the ability to change all domain aspects of the system.

10. RAAF CSS development should concentrate on supporting the business aspects specific to RAAF Command and Control. Generic aspects of applications can be provided by COTS products and services.

11. RAAF CSS should achieve a necessary balance between structured environments and those that provide flexibility, which support information-push as well as user-pull, and in which users' questions are processed transparently—with smart navigation tools supplied.

12. Rapid distributed decision-making is essential for air operations. RAAF CSS should provide tools for communicating and sharing complex information and knowledge.

13. RAAF CSS information flows may be formal or informal. Formal information flows may be supported by workflow models. Informal information flows are situation-dependent and are more difficult to pre-specify—it is important, therefore, that a CSS supports both formal and informal communications of information.

14. A RAAF CSS needs to support users in their situation awareness, situation assessment and planning. This requires sophisticated tools to be developed which are compatible with, and which meet, the changing demands of individuals and situations.

15. Development of RAAF CSS should proceed within sound technical frameworks compatible with the acquisition strategy planned. Should an evolutionary acquisition approach be adopted, several systems may be required for prototyping, testing, training and live-running.

16. RAAF CSS development accepts the capabilities which are currently operational. Strategies for migrating from current legacy systems to open systems, and for enhancing CSS functionality in doing so, need to be identified.

17. Computer hardware and communications are falling rapidly in price and becoming increasingly more powerful and capable. The challenge now is to produce more sophisticated and sympathetic support to users. If IS is the domain of information specialists and procurers, CSS should be the domain of its operators and users.

18. Security poses a major challenge for flexible CSS and IS development. For this reason, computer security, information security and CSS security are unlikely to be automated fully in the near future.

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19. Abstract

This report presents the results of a 12-month study by DSTO investigating the broad capabilities required of future RAAF Command Support Systems. A key finding is that broad capabilities can be specified, but user requirements are subject to change and environments are needed to support such changes. The broad capabilities are split into Command Support System capabilities and Information System capabilities to facilitate defining such environments.